Pribilof Red King Crab Model Scenarios and Responses to CPT
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Both the male-only model and two-sex model resulted in an abundance trend that was contrary to survey data. There is insufficient recruitment near the end of the time series to explain trends in the integrated assessment model.

A couple of slight clarifying points here: the estimated abundance trend is not contrary to survey data—it is within the error bounds and follows the size data from the survey well. Recruitment near the end of the time series is not sufficient to explain the increases in *observed survey numbers* (not the assessment)—there have been no new small crab in the system since 2004 and numbers of crab in a cohort generally do not increase over time.

The CPT hypothesized that highly varying survey estimates could be caused from a low density population combined with aggregation behavior of red king crab. An alternative hypothesis is that a variable portion of the stock is unavailable to the survey. The 3-year survey average approach attempts to address the issue of catching high numbers of crab in some years and missing crab aggregations in other years. The CPT expressed concern that, while in all years the CVs are high, years with low survey catches tend to have lower estimated CVs than high years. In reality, survey catches are probably equally uncertain every year.

I agree that the variability in the survey estimates of numbers is making assessment difficult. A 3-year average does smooth some of the variability out of the estimates of survey numbers, but poor conclusions can be made if the size data are ignored. Perhaps using a 3-year average for the survey estimated numbers (and associated CVs) within the integrated assessment would be an appropriate compromise. That said, I'm not sure if a 3-year average for the index in the integrated model would be able to fix the fits to the survey numbers data—the numbers data and the size data appear to be in conflict at some points. The most recent three years are a good example of this; very little recruitment has occurred since 2004, but the number estimates from the 3-year average in 2015 were one of the highest on record. This is hard to reconcile without considering a large immigration from elsewhere (probably not likely given the separation in the survey data between BBRKC and PIRKC) or large changes in catchability (which is an enticing hypothesis, but one for which we have few data).

The CPT noted that the stock assessment model results are shown in terms of abundance and requested that the model output be presented in terms of biomass to provide a comparison to model output using abundance. The CPT also noted that the survey data do not seem to play much of a role in the integrated assessment model. The CPT recommends a scenario down-weighting the length frequency data to see if fits to survey estimates improve. The CPT also recommends a scenario that applies uniform weighting across all survey years (i.e., either a constant CV or a constant standard error). While the CPT recommends further evaluation of the integrated length-based assessment for PIRKC, the CPT also discussed that a random effects model may be useful for this stock if it is to remain at a tier 4 level.

To be clear, is the CPT requesting that the assessment method be fit to biomass or just to present it in terms of biomass after fitting to numbers?

Down-weighting the length frequency data by multiplying the sample size in a given year by 0.5 did not improve the model fits substantially (compare figure 2 to figure 1). The model uses very high estimated trawl mortality (that results in estimated bycatches higher than those observed) to create a dip in numbers which is immediately filled by recruitment to get more of an 'upward' trajectory for the last several years of the estimated survey numbers trajectory. Decreasing the CVs of the survey numbers, down-weighting the catches and bycatches, and decreasing the weight on the size composition data allows the model to fit the survey numbers, but at the cost of nonsensical fishing mortalities and poor fits to the catch (Figure 3). Changing to constant CVs for the survey numbers did not impact the fits—the CVs are already relatively close in magnitude (save a couple of years). The survey numbers can be fit, but only by predicting catches that are orders of magnitude above those which were observed and feeding the model recruitment in the final years of the model orders of magnitude above historical recruitment.

I don’t think fitting the survey numbers estimates at the cost of not fitting the length data is a good idea. A ‘signal’ exists in the length data—we very clearly see cohorts progressing through the size classes. No clear signal exists in the estimated survey numbers (save that something ‘big’ happened in the late 1980s). The fishery didn’t seem to have a clear impact on the population—the estimated $F_{35\%}$ is 0.44 and the estimated F *almost* reached 0.4 in 1993; all other years were far below that. Even looking at the ‘raw’ estimated survey numbers, the estimates of numbers actually increased the two years after the year in which the fishery was most intense.

The CPT recommends for 2015 using the status-quo 3-year running average weighted by the inverse of the variance of the area-swept estimate. The 3-year weighted average assessment uses the inverse of the variance, but it may be more appropriate to use the arithmetic mean to avoid skewing the estimates towards years when survey catches are low. The CPT recommends a 3-year average weighted by standard errors and a random effects model be presented in May 2016.
Jack said he will do this for September 2016.

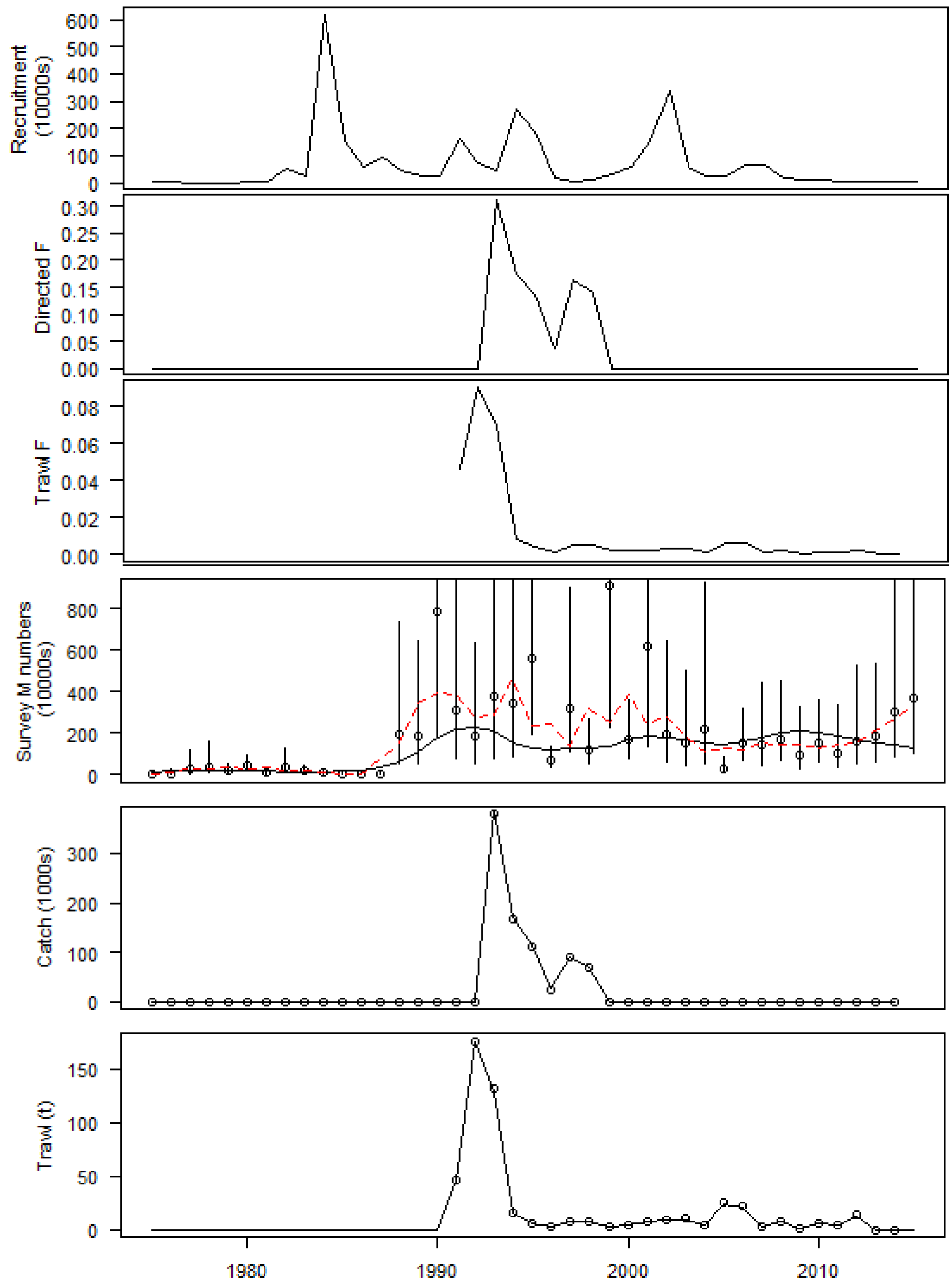

Figure 1. Original weighting on size distribution (i.e. using the actual number of samples unless it is over 200, at which point the sample size is fixed at 200). Red dashed line is 3-year average, solid black line is the estimated quantity from the integrated assessment.

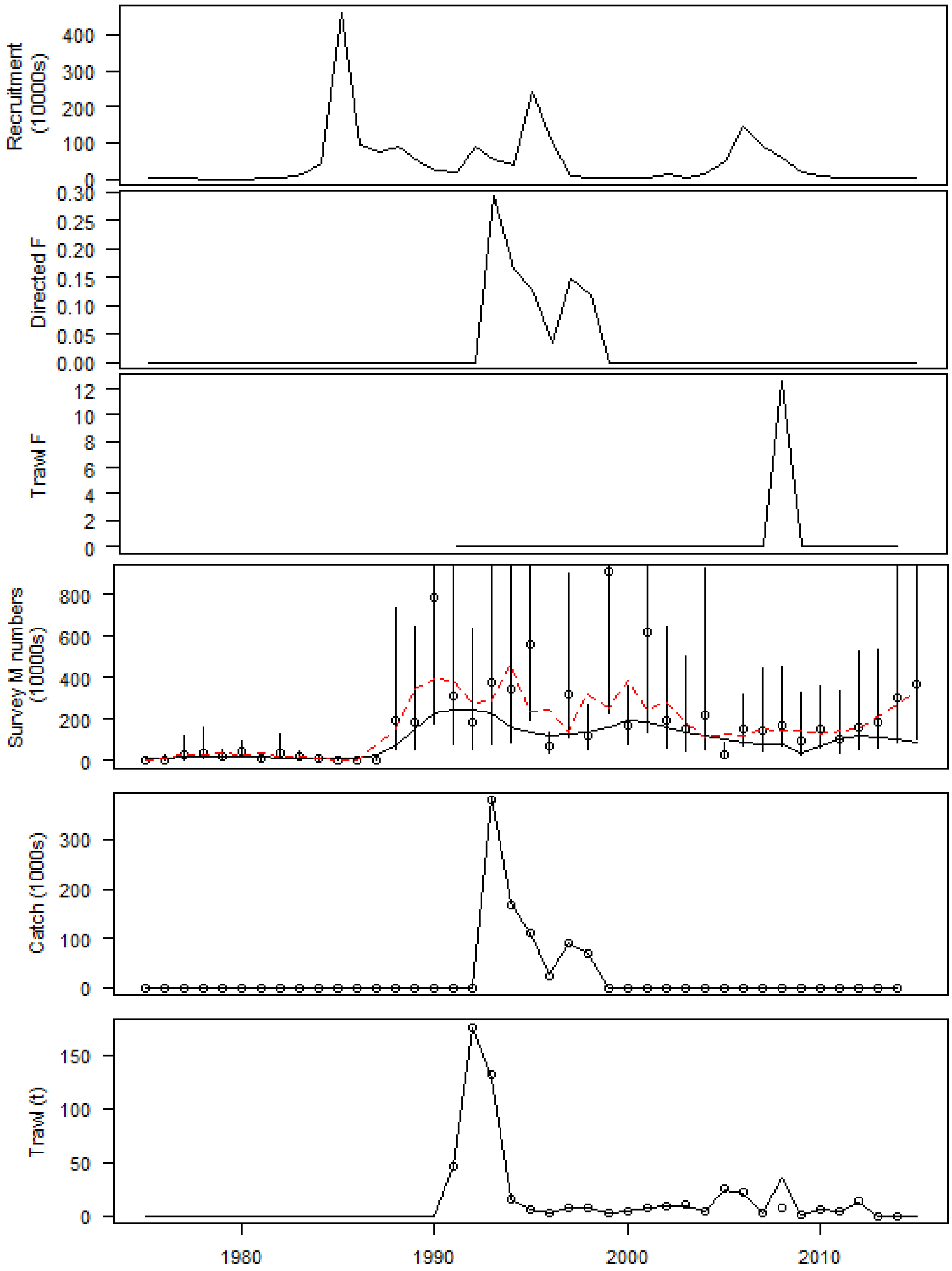

Figure 2. Halve the sample size for size distribution. Red dashed line is a 3-year average, solid black line is the estimated quantity from the integrated assessment.

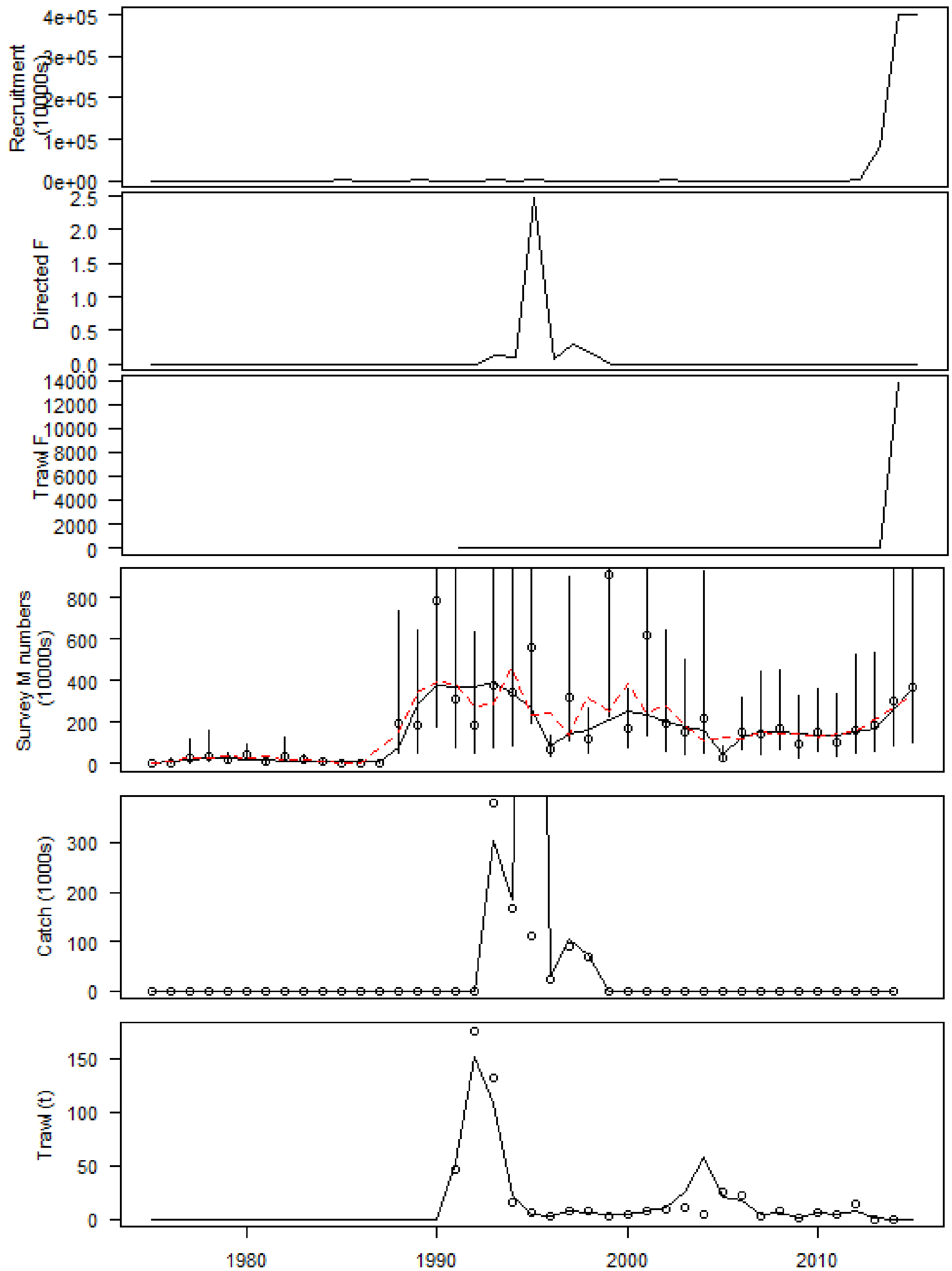

Figure 3. Decrease CVs on survey numbers and weight on catch and bycatch by an order of magnitude, halve the weight on length frequencies. Red dashed line is 3-year average, solid black line is the estimated quantity from the integrated assessment.